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PRELIMINARY STUDY
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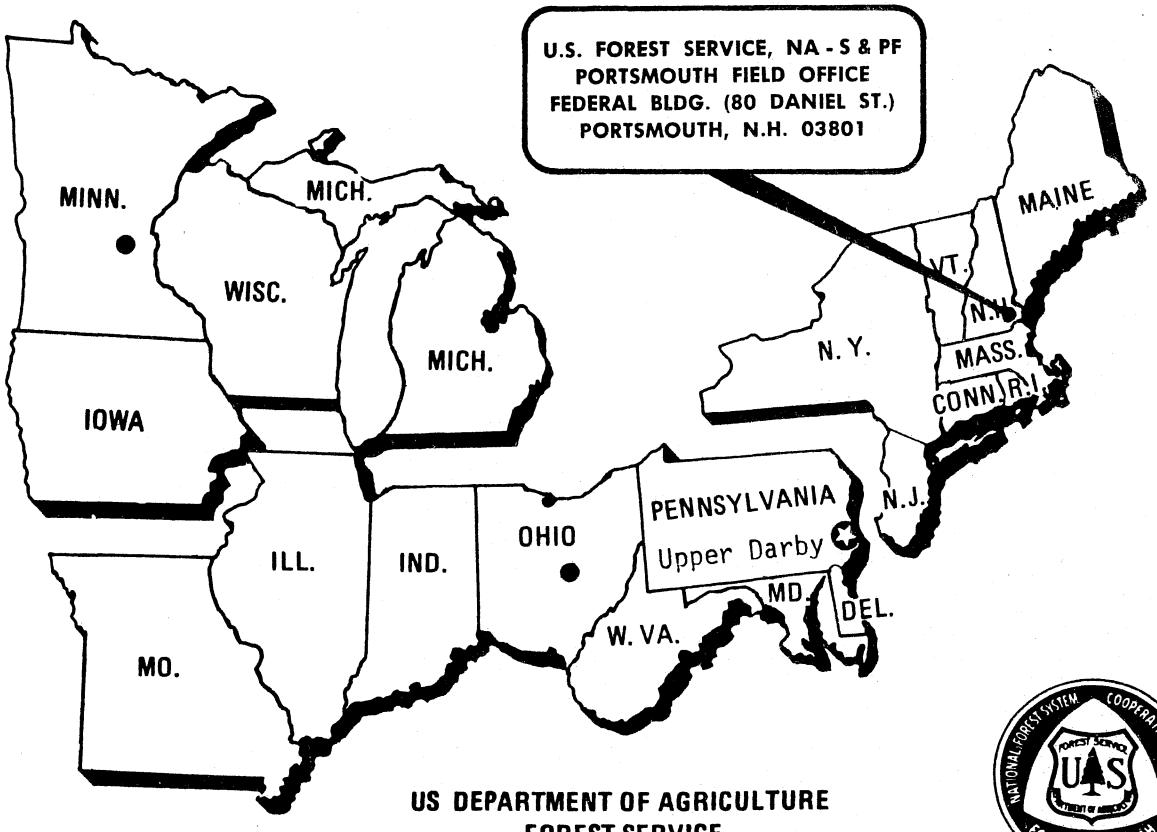

US DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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HOST PREFERENCE FOR EGG DEPOSITION BY THE ELM SPANWORM, ENNOMOS SUBSIGNARIUS (HBN.)

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ABSTRACT

From 1969 to 1972 a major outbreak of elm spanworm occurred in Connecticut and New York. This study was conducted in April 1972 to determine host tree preference for egg deposition by the elm spanworm, Ennomos subsignarius (Hbn.) in mixed stands containing yellow-poplar, red maple, and red oak trees on three State Forests in Connecticut. Egg masses were counted on 240 randomly selected branches (20 plots). Egg mass populations were aggregated at high population levels in severely defoliated areas. Results of this study indicate that adult females prefer ovipositing on red maple branches rather than on red oak or yellow-poplar.

INTRODUCTION

The elm spanworm, Ennomos subsignarius (Hbn.), also called the snow-white linden moth, a native insect of the Northeastern U. S., is a polyphagous defoliator of hardwoods in Eastern United States and Southeastern and South Central Canada. Between 1878 and 1972 more than 20 major outbreaks have been recorded in Eastern North America with a minimum of two every decade. In 1960 and 1961 over 1½ million acres were affected in Georgia, North Carolina and Tennessee[6/]. More recent outbreaks of the elm spanworm occurred between 1969 and 1972 during which more than 1,300,000 acres of woodlands and forests in Connecticut and New York were moderately to severely defoliated.

The elm spanworm feeds on ash, hickory, walnut, and oak, but will feed on a large number of other hardwoods. Repeated defoliation results in growth reduction and tree mortality[6/7/]. Other adverse effects caused by this insect are loss of shade, loss of esthetic value of trees, and the nuisance of larvae spinning down from trees and invading forests, woodlands, and ornamental shade trees. Spectacular mass flights of the moths invade towns and cities, creating a "snow storm" effect in the summer. Since the eggs remain on the trees for 9 to 10 months, sampling the insect in this stage is advantageous in ascertaining oviposition host preference which could lead to predicting potential population trends for the following season.

PURPOSE AND SCOPE

Although larvae feed indiscriminately on various host trees, attacking virtually all broad-leaved plants except yellow-poplar, egg deposition is more defined, i.e., the female oviposits on the underside of twigs, branches, and even the trunks of specific host trees.

An egg mass sampling technique was developed by Drooz and Solomon at the Southeastern Forest Experiment Station, U. S. Forest Service[3/]. This study was conducted to determine if their sampling system is applicable in the Northeast.

Drooz and Soloman used 5-foot branch samples from the lower half of the crown of red oak (group), white oak (group) and hickories, as a basic unit in collecting elm spanworm egg masses. They found that the mean number of eggs per mass on the oak tended to be greater than that for the hickories. Also greater numbers of masses were found on the 0.4 to 0.6-inch branch diameters. Few egg masses were located on the first foot of the branches from the terminal bud. In North Carolina, Georgia, and Tennessee where their work was conducted, no significant difference in the number of egg masses from red and white oaks was found. However, a significant difference in host preference was detected for the red and white oak groups over the hickories[3/].

DESCRIPTION OF ELM SPANWORM EGG MASS

Adult female moths usually oviposit in July, eggs being laid in irregular compact masses. Usually 50 to 100 eggs are laid on the underside of twigs, branches and even on the trunk of host and non-host trees. These eggs are about 1/25-inch long and somewhat barrell-or key-shaped (Illus. 1). They are bright olive-green when laid, but as they age, darken and often attain a bronze or grayish cast. Previous year's egg masses are dull and will have an accumulation of dirt, soot, and other debris on them. Also, a few will be unhatched.

HOST TREES SAMPLED

Red maple, *Acer rubrum* L.

Northern red oak, *Quercus rubra* L.

Yellow-poplar, (tulip tree), *Liriodendron tulipifera* L.

The forest type where elm spanworm egg masses were collected was composed of oak-maple stands in Connecticut, with yellow-poplar invariably the associated species.

Illus. 1.
Egg masses of elm spanworm on a branch of yellow-poplar. Note operculum around top of the eggs through which eclosion will occur.

SAMPLE AREAS

Egg masses were collected on Cockaponset, Paugussett, and Naugatuck State Forests, Connecticut in April 1972 on red maple, red oak, and yellow-poplar (maps 1-3). Where possible, egg masses were collected outside areas which were infested with gypsy moth to prevent any compounding of the data.

METHOD OF SAMPLING

The basic sampling unit was a branch five feet in length taken from the lower crown of each sample tree. Four such branches were taken from each sample tree, using a 36-42 foot pole pruner.

Each plot consisted of three trees; one red maple, one red oak, and one yellow-poplar. A total of 20 plots (240 branches) were sampled.

Branch samples were taken at random without regard to crown index, tree height, quadrant, or degree of slope. Egg masses were counted and recorded as shown in Table 1.

TABLE 1

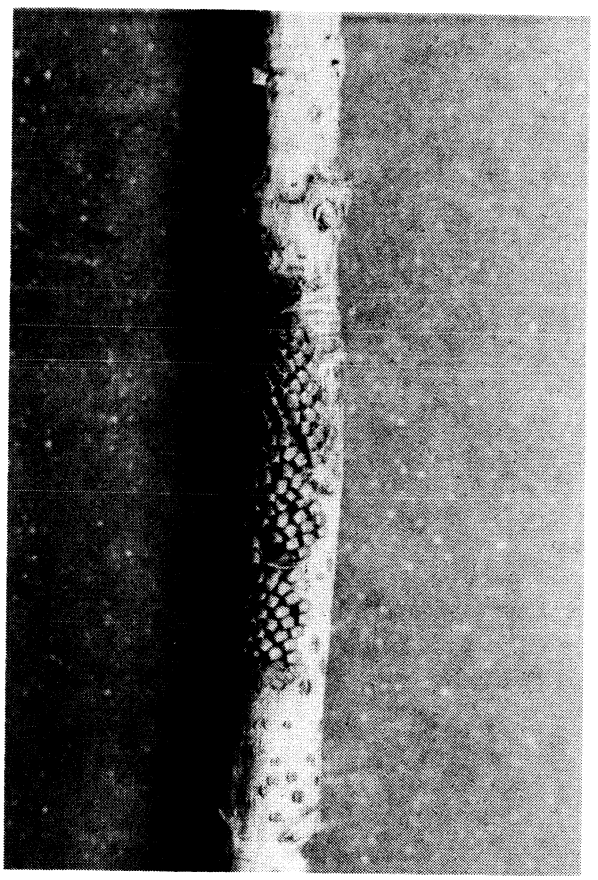
ELM SPANWORM - OVIPOSITION HOST PREFERENCE STUDY-1972

DATE: April 5 to May 1, 1972

PLOT LOCATION: Plot No. 1-2; Paugusett State Forest, Conn.
Plot No. 3-9; Naugatuck State Forest, Conn.
Plot No.10-20; Cockaponset State Forest, Conn.

Egg Mass Counts (Per Quadruple)
Five Foot Branch Samples

Plot Number	TREE SPECIES											
	YELLOW POPLAR Branch				RED MAPLE Branch				RED OAK Branch			
	1	2	3	4	1	2	3	4	1	2	3	4
1	9	9	0	4	9	0	2	5	2	3	5	7
2	6	10	0	5	1	1	0	0	0	0	0	0
3	0	4	0	4	10	5	6	4	0	0	0	0
4	0	0	0	0	0	0	2	2	0	0	1	0
5	0	0	4	0	2	2	0	0	0	0	0	0
6	0	0	0	1	1	3	11	8	0	0	0	3
7	0	0	1	2	3	1	1	3	0	0	0	1
8	3	0	4	4	0	1	3	0	1	0	1	0
9	0	0	2	3	27	7	12	6	0	0	0	0
10	5	0	2	5	0	1	0	0	0	0	0	2
11	7	4	1	2	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	3	4	0	4	0	0	0	0
14	0	1	0	0	1	3	3	4	1	3	2	2
15	1	0	0	0	1	1	3	1	0	0	0	0
16	0	0	0	0	1	1	1	1	1	0	0	0
17	0	0	0	0	0	0	0	0	0	3	2	1
18	1	0	1	1	0	2	0	1	0	0	0	0
19	0	0	0	0	0	1	0	0	0	0	0	0
20	0	1	1	1	0	1	0	1	0	0	0	0



Illus. 2.

Egg masses of elm spanworm on a red maple branch. Lack of operculum indicates that the eggs were parasitized.

TABLE 2

EGG MASS COUNTS PER FOUR 5-FOOT BRANCH SAMPLES OF YELLOW-POPLAR, RED MAPLE, AND RED OAK IN TWENTY PLOTS (DATA FROM TABLE 1)

	TREE SPECIES		
Plot No.	Yellow Poplar	Red maple	Red oak
1	22	16	17
2	21	2	0
3	8	25	0
4	0	4	1
5	4	4	0
6	1	23	3
7	3	8	1
8	11	4	2
9	5	52	0
10	12	1	2
11	14	0	0
12	0	0	0
13	1	11	0
14	1	11	8
15	1	6	0
16	0	4	1
17	0	0	6
18	3	3	0
19	0	1	0
20	3	2	0
TOTALS	110	177	41

Each sample tree was numbered and flagged, and the area and location of each plot was recorded on a topographic or county map to facilitate revisitation of the trees and plots if necessary.

ANALYSIS OF DATA

In determining the type of distribution of egg masses collected from each host tree, egg masses per branch were arranged in a frequency table by species. Plotting egg mass frequency over number of egg masses revealed skewness far to the left for each tree species (Fig. 1). This trend indicated that the distribution was not a normal one. Transforming the data to the log of X+1 or square root of $\sqrt{X+0.5}$ did not improve the relationship. It was necessary to use the 4 branches per tree as the sampling unit. The frequency of egg masses per plot (4 branches per tree) is shown in Table 2.

Table 3 shows the frequency number of egg masses observed on four 5-foot branch samples of each host species.

TABLE 3

FREQUENCY NUMBER OF ELM SPANWORM EGG MASSES PER FOUR 5-FOOT BRANCH SAMPLES OF YELLOW-POPLAR, RED MAPLE, AND RED OAK. TOTAL NUMBER OF BRANCHES SAMPLED WAS 240.

Frequency Number Egg Masses	Total Number of Egg Masses Occurring on Each Host Species		
	Yellow Poplar	Red Maple	Red Oak
0	47	32	63
1	12	19	6
2	4	6	5
3	2	8	4
4	7	4	0
5	3	2	1
6	1	2	0
7	1	1	1
8	0	1	
9	2	1	
10	1	1	
11		1	
12		1	
13+		1	
TOTAL	80	80	80
$\bar{X}$ (true)	1.38	2.03	0.50
s^2	5.90	9.49	1.98

A Chi-square test of independence indicated that with untransformed data, there was a significant difference in egg mass counts among tree species. The computed value of Chi^2 was 46.9 (2 degrees of freedom) at 0.01 level.

A comparison of the observed distribution to the expected negative binomial distribution was tested using Chi^2 for each host species. There was no significant difference between the observed and expected distribution. The computed values of the Chi^2 test are shown below:

Host Species	Chi^2 Value	Degrees of Freedom	Probability Level	Table Value
Yellow-poplar	16.27	7	99%	18.48
Red maple	7.14	10	99%	23.21
Red oak	12.99	4	99%	13.28

The calculated values of k, using Southwood's method #2 were 0.226 for yellow-poplar, 0.513 for red maple, and 0.082 for red oak. Fifteen egg mass counts were randomly selected from the original data, means and variance were computed and then plotted on graph paper. The trend of the plotted points indicated that the distribution was a negative binomial (Fig. 2). Transforming the original data using $y=\log_{10}(X+1)$ destroyed the relationship between the mean and variance (Fig. 3) and the distribution is now random. Since this transformation appears appropriate for the data, the original data was not used for any further statistical analysis.

A set of t tests (unpaired) using the transformed data was used to isolate the difference in egg mass counts between tree species. The results at 0.05 level of probability indicated a significant difference between host species preferred for oviposition by the elm spanworm. The computed values of "t" for the three host species are shown below:

Species Comparison	Calculated t
Yellow-poplar vs red oak	3.02*
Red maple vs yellow-poplar	3.38*
Red oak vs red maple	4.98*

*Significant at the 5% level for 38 d.f. where t = 2.02.

RESULTS

Results of this study indicate that adult females prefer ovipositing on red maple branches rather than on red oak or yellow-poplar. The probability of finding elm spanworm is higher when sampling 5-foot branches of red maple rather than when sampling yellow-poplar or red oak. Yellow-poplar was preferred over red oak for elm spanworm egg deposition, although it is relatively immune to attack by the larvae.

DISCUSSION

Like most insects and other animals, elm spanworm egg mass populations are not distributed randomly but are aggregated. Sampling host trees in severely defoliated areas did not necessarily indicate that high egg mass counts would be present on every branch of the host tree. It was not unusual to find only a few egg masses on host tree branches when intensively sampling. Yet, adjacent host trees would have a high egg mass population on both branches and trunk. Several possible explanations for this aggregation may be (1) response of the insect to host plant or parts thereof; (2) response of the insect to physical factors of the environment, such as light, temperature, and humidity; (3) mutual attraction with other individuals of the same species (e.g., gregariousness, mating behavior).

Red maple and red oak trees sampled in this study were in the intermediate or dominant class, averaging 6" to 10" dbh with low crown ratio, while yellow-poplar was in the co-dominant and dominant crown class with high crown ratio.

CONCLUSIONS

Extensive literature is available on the elm spanworm, but biological knowledge of this insect and its microhabitat is still not fully understood. A probable explanation may be erratic buildups and widely separated periods of extreme scarcity of repeated outbreaks within the same locality[6/].

Some host trees highly preferred by elm spanworm for oviposition in the Northeast are red maple and yellow-poplar while in Georgia, North Carolina, and Tennessee, highly preferred host trees were white oaks (group) or red oaks (group) rather than the hickories. According to this study, the method utilized by Drooz and Solomon is applicable in the Northeast provided egg masses are collected in severely defoliated areas.

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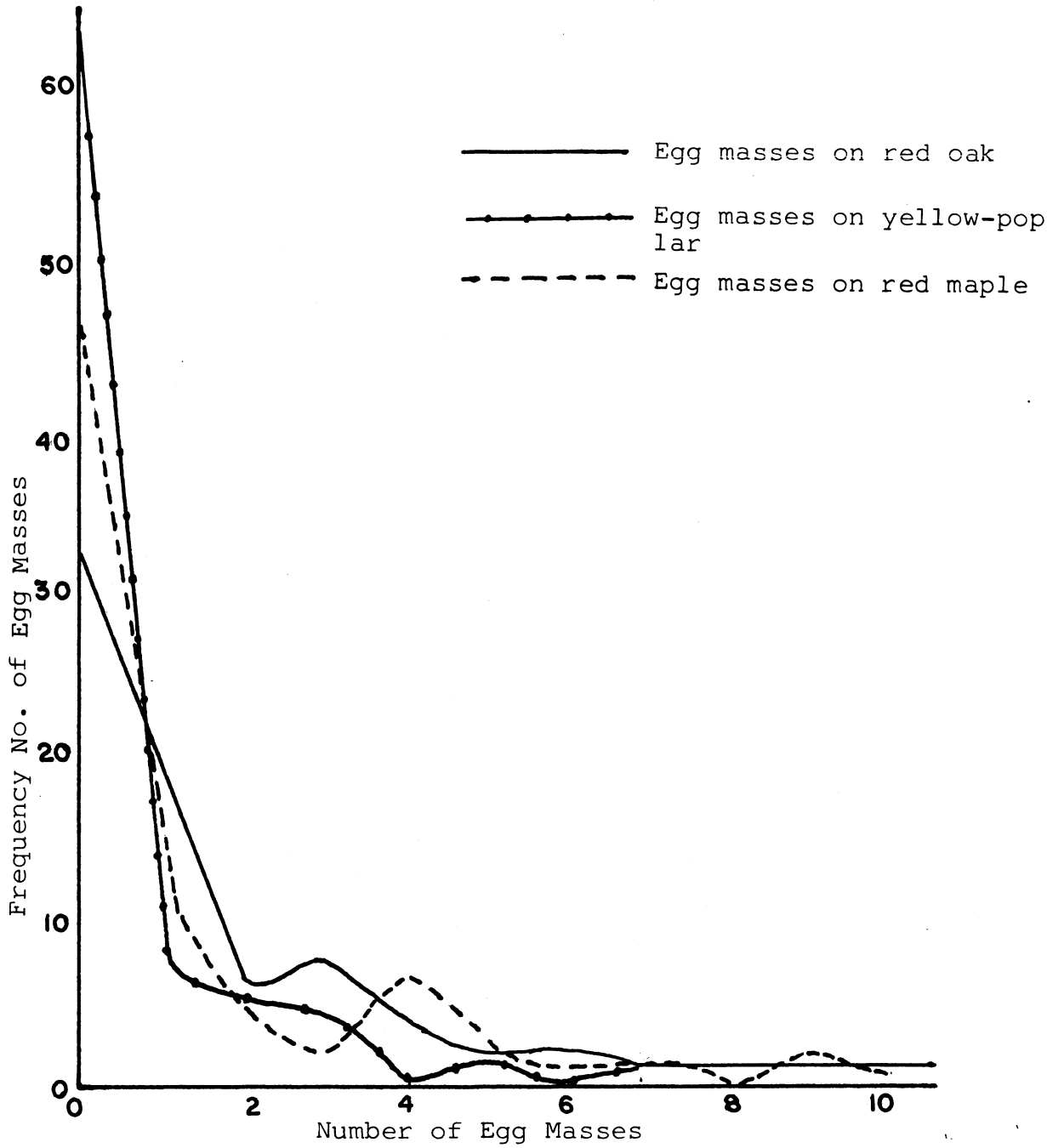
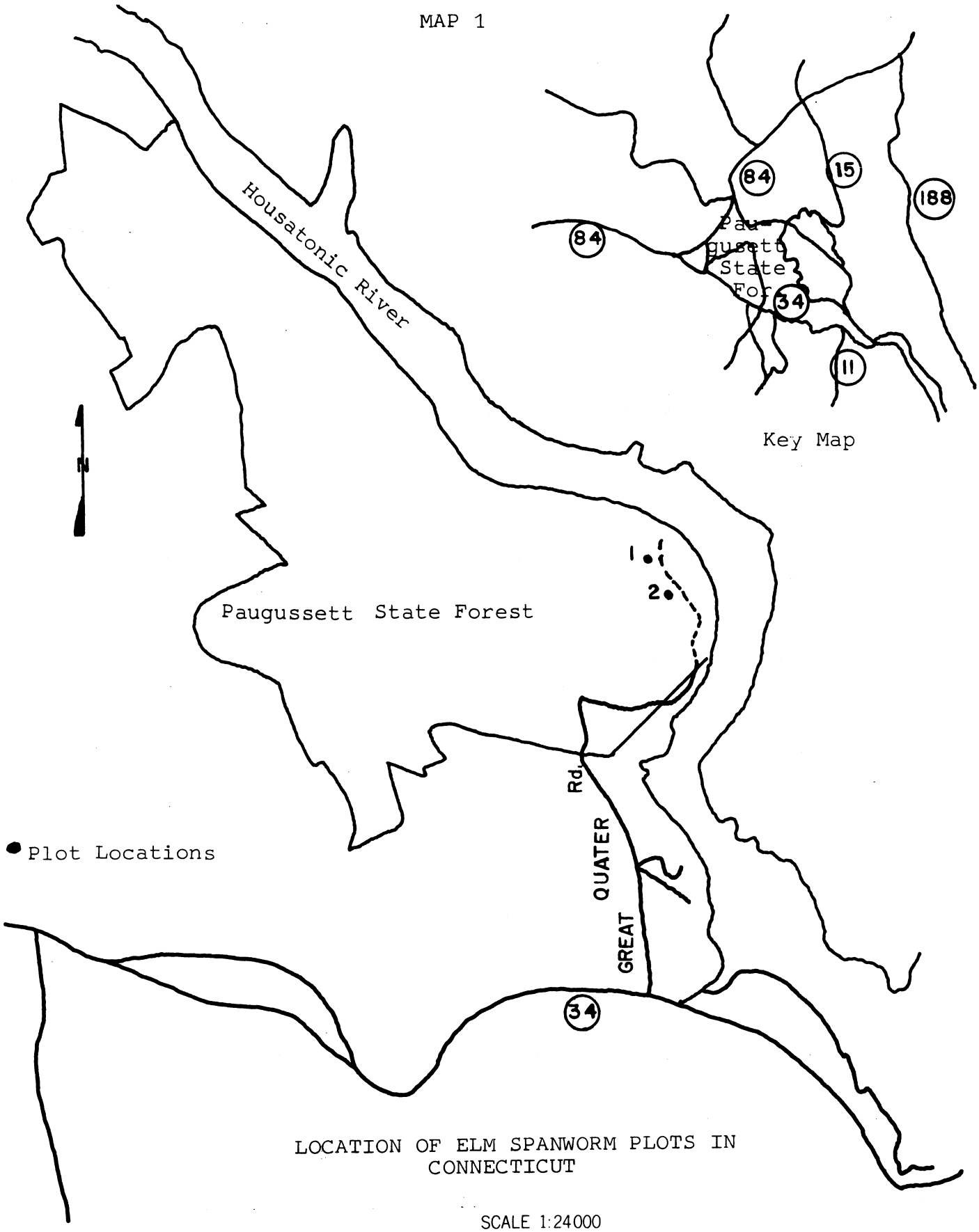


Fig. 1. Relationship between number of egg masses and frequency number of egg masses on 5-foot branch samples of yellow-poplar, red maple, and red oak.

MAP 1



LOCATION OF ELM SPANWORM PLOTS IN CONNECTICUT

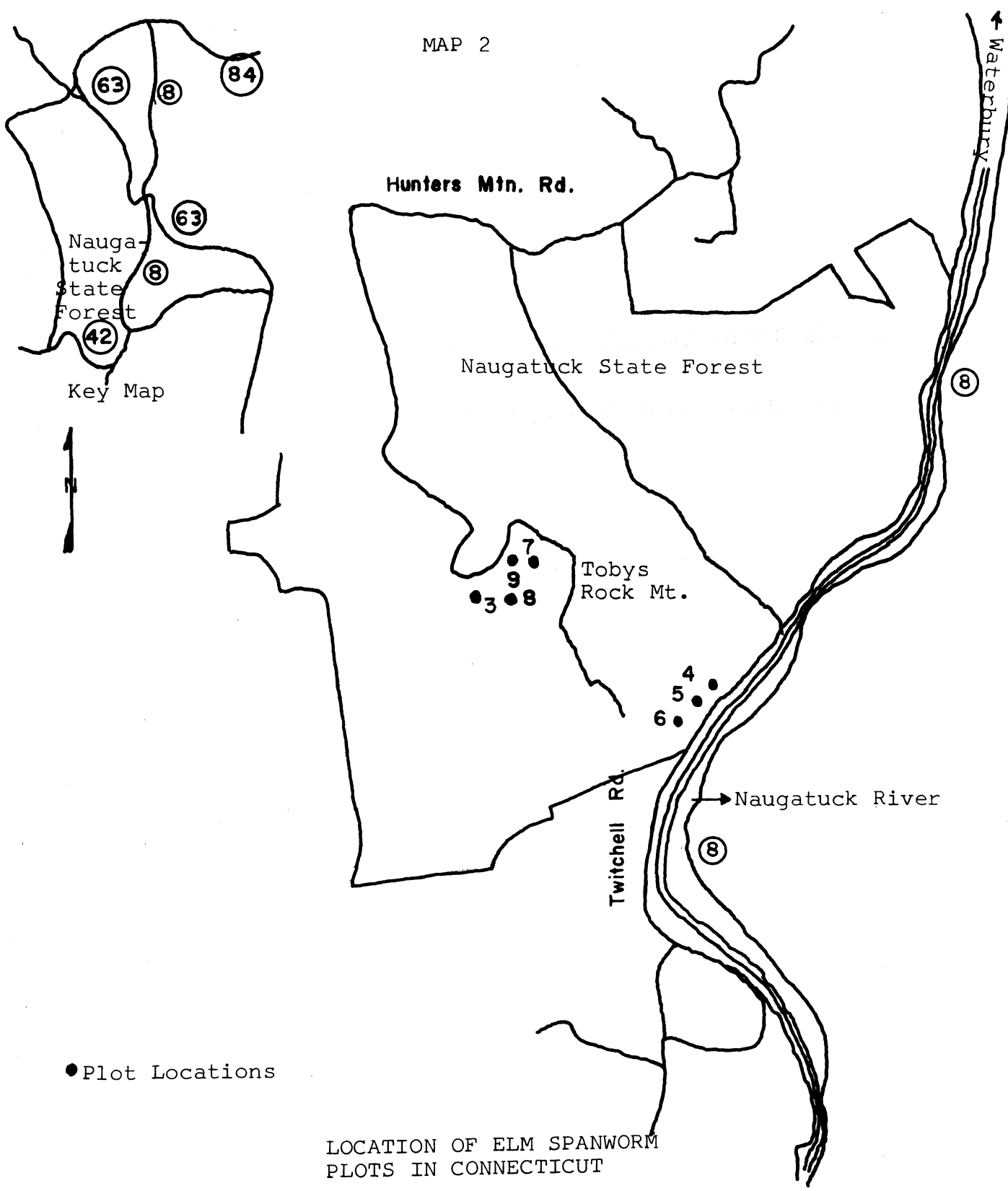
SCALE 1:24000

1 0 1/2 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

MAP 2



LOCATION OF ELM SPANWORM PLOTS IN CONNECTICUT

SCALE 1:24000

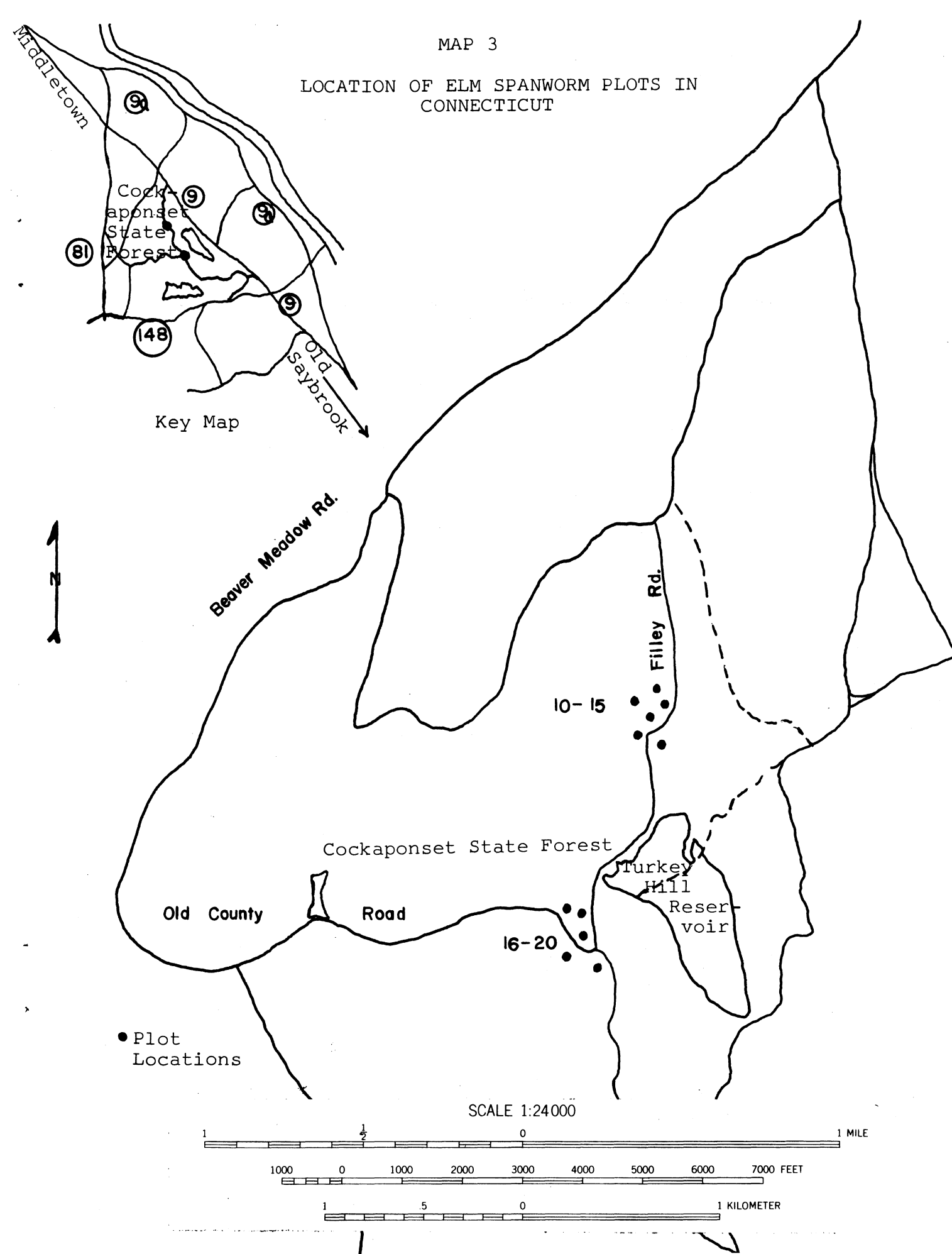
1 0 ½ 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

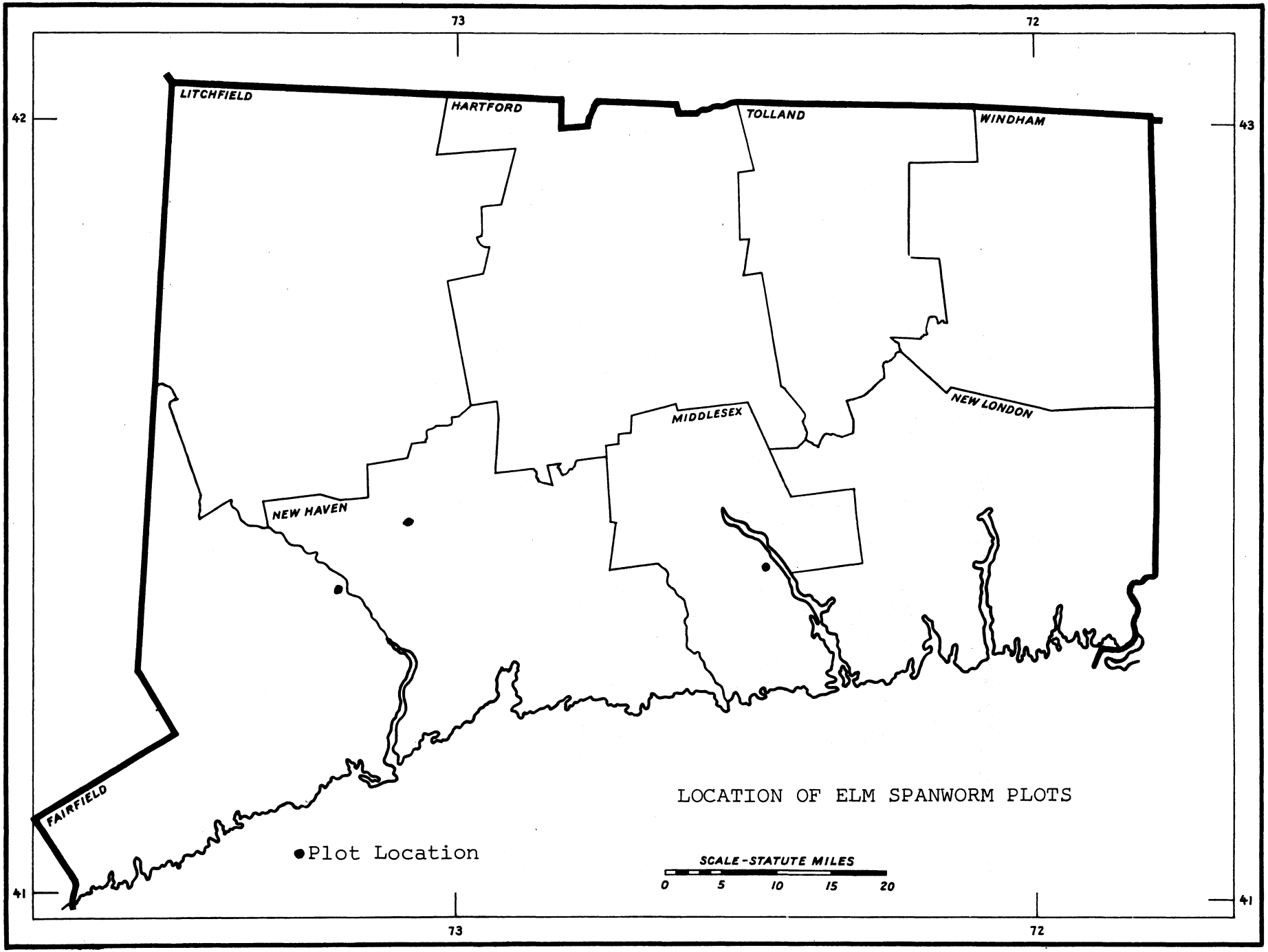
1 .5 0 1 KILOMETER

MAP 3

LOCATION OF ELM SPANWORM PLOTS IN CONNECTICUT



MAP 4. --- CONNECTICUT



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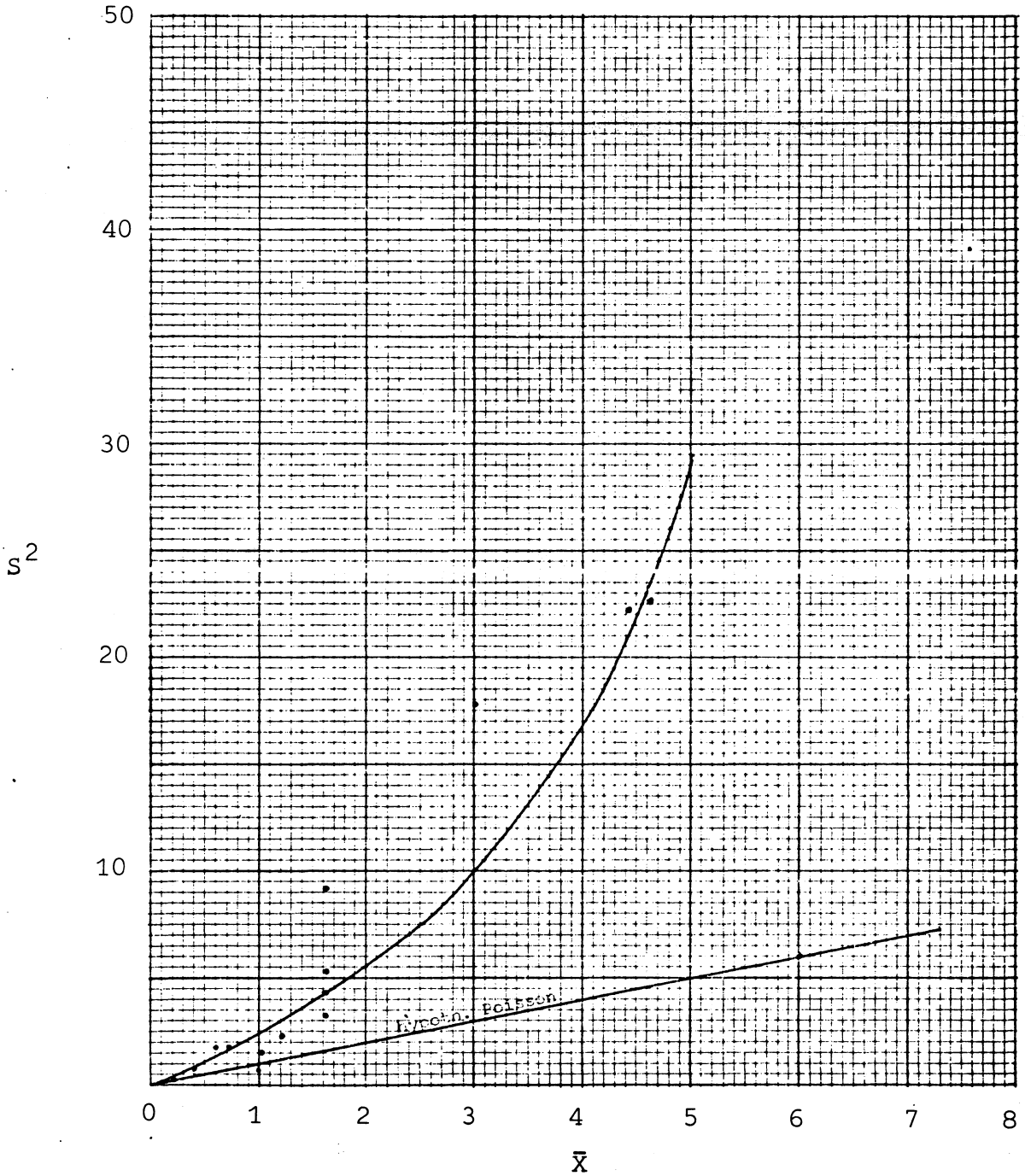

Fig. 2. Relationship between variance and mean for elm spanworm egg mass population. Each point plotted is based on four 5-foot branch samples.

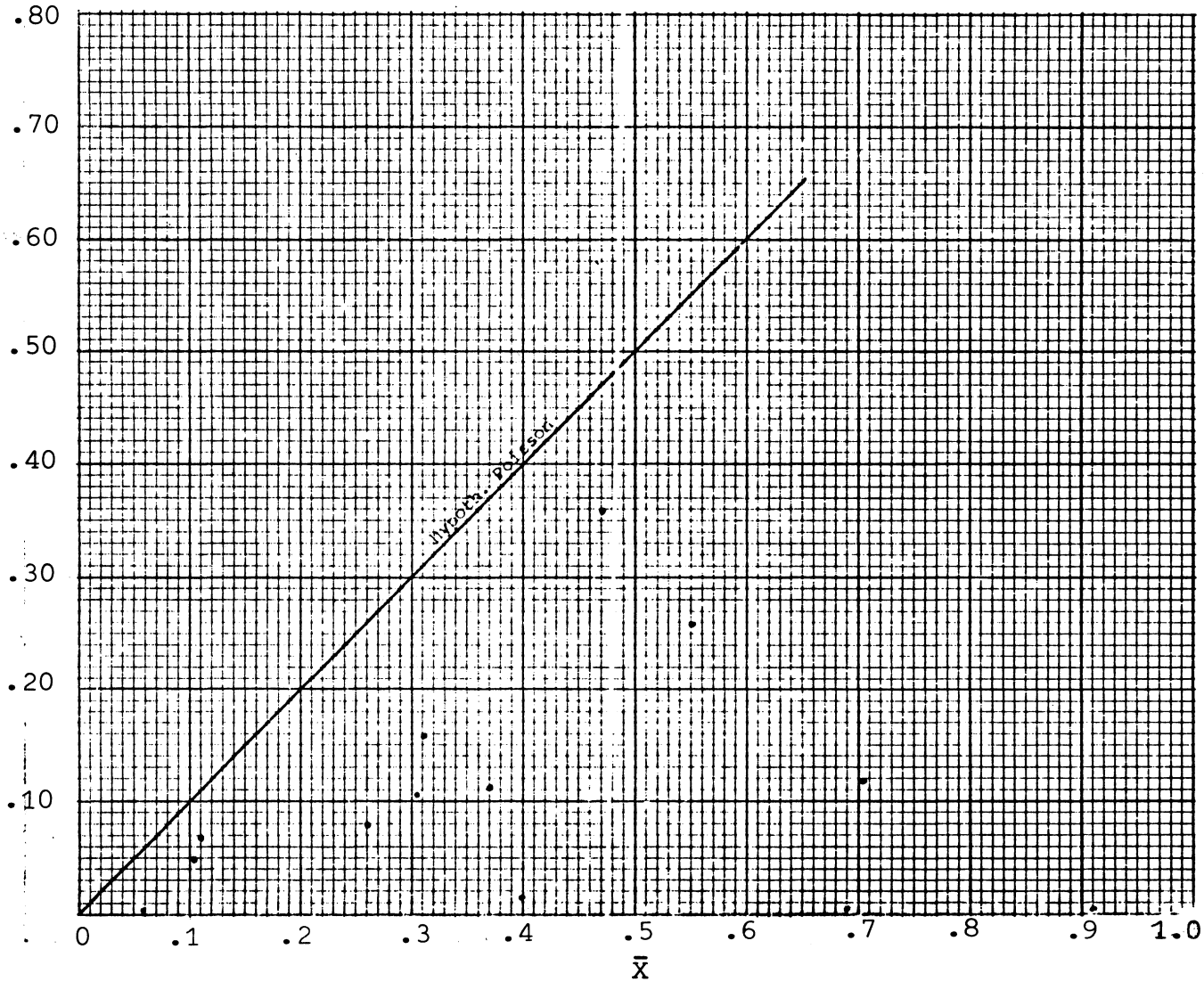

Fig. 3. Variance (S^2) over mean ($\bar{X}$) for egg mass population data (Fig. 2.) following transformation to y=log (x+1)